SOLENOID CONTROLLER

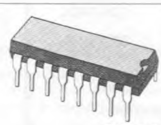
- DRIVES ONE OR TWO EXTERNAL DARLINGTONS
- DUAL AND SINGLE LEVEL CURRENT CONTROL
- SWITCHMODE CURRENT REGULATION
- ADJUSTABLE PEAK DURATION
- WIDE SUPPLY RANGE (4.75-46 V)
- TTL-COMPATIBLE LOGIC INPUTS
- THERMAL PROTECTION

DESCRIPTION

The L5832 Solenoid Controller is designed for use with one or two external darlington transistors in solenoid and relay driving applications.The device is controlled by two logic inputs and features switchmode regulation of the load current. A key feature of the L5832 is flexibility.

It can be used with a variety of darlingtons to match the requirements of the load and it allows both simple and two level current control Moreover, the drive waveshape can be adjusted by external components. Other features of the device include thermal shutdown, a supply voltage range of 4.75-46 V and TLL-compatible inputs.

The L5832 is supplied in a 12 + 2 + 2 – lead Powerdip package which use the four center pins to conduct heat to the PC board copper.



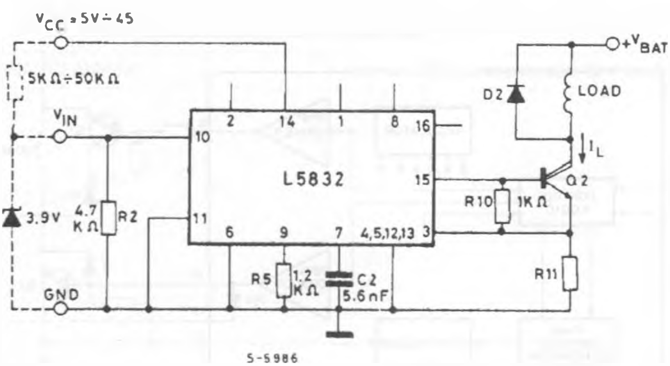
Powerdip
12 + 2 + 2

ORDER CODE : L5832

THERMAL DATA

$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	Max.	14	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	80	°C/W

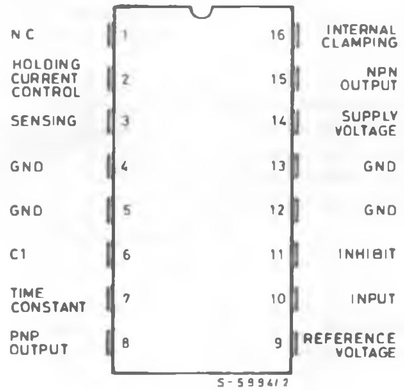
APPLICATION CIRCUIT USING ONE DARLINGTON



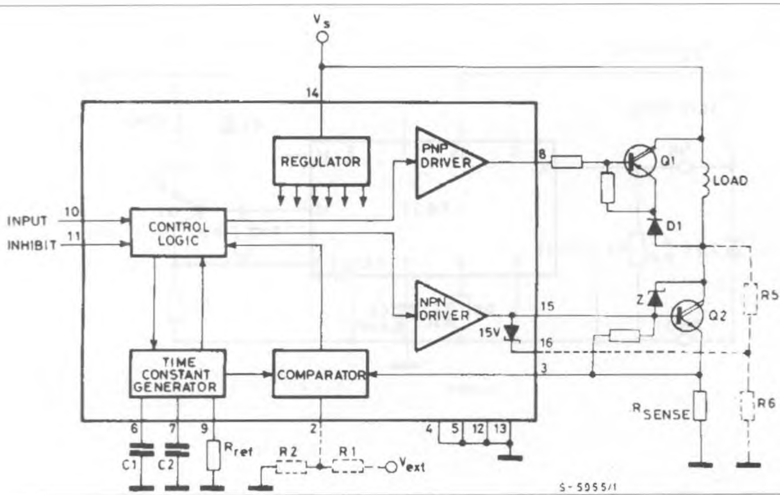
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	46	V
V_8	Positive Transient Voltage at Pin 8	60	V
V_{en}	Enable Input Voltage (pin 11)	7	V
V_I	Input Voltage (pin 10)	7	V
V_R	External Reference Voltage (pin 2)	2	V
P_d	Power Dissipation (T_{case} = 80 °C)	5	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

CONNECTION DIAGRAM



BLOCK DIAGRAM



PIN FUNCTIONS

N	Name	Function
1	NC	Not Connected. Must be left open circuit.
2	HOLDING CURRENT CONTROL	A voltage applied to this pin sets the holding current level. If left open circuit an internal 75 mV reference is used and $I_h = I_p/6$.
3	SENSING	Connection for Load Current Sense Resistor. Value sets the maximum load current. $I_p = 0.45/R_S$.
4	GROUND	Ground Connection. With pins 5, 12 and 13 conducts heat to printed circuit board copper.
5	GROUND	See Pin 4
6	C1	A capacitor connected between this pin and ground sets the duration of the current peak (t2 in fig.3). If left open, the switchmode control of the peak is suppressed. If grounded, the current does not fall to the holding level.
7	DISCHARGE TIME CONSTANT	A capacitor connected between this pin and ground sets the duration of t_{off} (fig.3). If grounded, switchmode control is suppressed.
8	PNP DRIVING OUTPUT	Current Drive Output for External PNP Darlington (for recirculation). $I = 35\ I_{ref}$.
9	REFERENCE VOLTAGE	A resistor connected between this pin and ground sets the internal current reference, I_{ref}. The recommended value is 1.2kΩ, giving $I_{Ref} = 1$ mA.
10	INPUT	TTL - Compatible Input. A high level on this pin activates the output, driving the load.
11	INHIBIT	TTL - Compatible Inhibit Input. A high level on this input disables the output stages and logic circuitry, irrespective of the state of pin 10.
12	GROUND	See Pin 4
13	GROUND	See Pin 4
14	SUPPLY VOLTAGE	Supply Voltage Input
15	NPN DRIVING OUTPUT	Current Drive for External NPN Darlington (in series with the load). $I = 100\ I_{ref}$.
16	INTERNAL CLAMPING	Internal Zener Clamp Avaible for Fast Turnoff.

ELECTRICAL CHARACTERISTICS ($V_{S\,(pin\,14)}$ = 14 V , T_{amb} = 25 °C, R_{ref} = 1.2 KΩ, unless otherwise specified. Refer to Fig.2)

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
V_S	Operating Supply Voltage (pin 14)			4.75		46	V
I_S	Quiescent Current (pin 14)	$V_{pin\,10} = V_{pin\,11}$ = Low State			21	40	mA
V_{in}	Input Voltage (pin 10)	Low State				0.8	V
V_{en}	Enable Input Voltage (pin 11)	High State		2.4			V
I_{in}	Input Current (pin 10)	Low State				100	μA
I_{en}	Enable Input Current (pin 11)	High State				10	μA
V_{ref}	Internal Reference Voltage (pin 9)			1.2	1.25	1.3	V
I_{ref}	Reference Current (pin 9)	$I_{ref} = V_{ref}/R_{ref}$ R_{ref} = 1.2 KΩ				1 300	μA
I_{pd}	Peak Duration Control Current (pin 6)	$I_{pd} = I_{ref}/8$		110	130	180	μA
t_{pd}	Peak Duration Time (pin 6)	$t_{pd} = C1\ V_{Th}/I_{pd}$ V_{th} = 1.4V C₁ = 4.7 nF			500		μs
I_{od}	Off Duration Control Current (pin 7)	$I_{od} = I_{ref}$ / 8		110	130	180	μA
t_{off}	Off Duration Time (pin 7)	$t_{od} = C2\ V_{th}/I_{od}$ V_{th} = 1.4V C2 = 4.7 nF			50		μs
I_{d1}	NPN Driving Current (pin 15)	$I_{d1} = 100\ I_{ref}$ (only present during charging phase)		80	100	130	mA
I_{d2}	PNP Driving Current (pin 8)	$I_{d2} = 35\ I_{ref}$		28	35	48	mA
I_p	Peak Current (emitter of NPN Darlington)	I_p = 450 mV/R_{sens} R_{sens} = 0.1 Ω		4.2	4.5	4.8	A
V_h	Holding Current Control Voltage	$V_h = R_{sens}\ I_h$ I_h = Emitter Current of NPN Darlington	Pin 2 Floating	70	75	85	mV
			Pin 2 Externally Biased			2	V
R_{in}	Holding Current Control Input Impedance (Pin 2)			100	150	200	Ω
r	Peak to Hold Current Ratio	Pin 2 Floating		5.8	6	6.2	
			Pin 6 Shorted	0.97	1	1.03	
I_B	Sense Input Bias Current (Pin 3)					100	μA
V_{clamp}	Internal Clamping (Pin 16 to 15)	I = 200 μA		14	16	18	V
V_{dt}	Dump Protection Threshold Voltage (Pin 1)			28	32	34	V
R_{dt}	Dump Protection Threshold Input Impedance (Pin 1)			22	32	42	KΩ
	Thermal Drift of Reference Voltage				0.5		mV/°C

APPLICATION INFORMATION

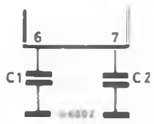
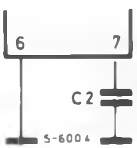
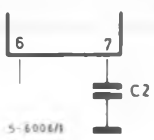
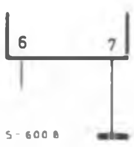
The L5832 solenoid controller is intended for use with one or two external darlington transistors to drive inductive loads such as solenoids, relays, electric valves and DC motors.

Controlled by a logic input and an inhibit input (both TTL compatible), the device drives the external darlington (s) to produce a load current waveform as shown in figure 3. This basic waveform shows that the device produces an initial current peak followed by a lower holding current. Both the peak and holding current levels are regulated by the L5832's switchmode circuitry .

The duration of the peak, the peak current level and holding current level can all be adjusted by external components.

Moreover, by omitting C1, C2 or both it is possible to realize single-level current control, a transitory peak followed by a regulated holding current or a simple peak (figure 1).

Figure 1 : Components Connected to Pins 6 and 7 Determine the Load Current Waveshape.

COMPONENTS ON PINS 6 AND 7	LOAD CURRENT WAVEFORM
	
	
	
	

The peak current level I_p, is set by the sensing resistor, R_{sens}, and is found from :

$$I_p = \frac{0.45}{R_{sens}}$$

The holding current level, I_h, is set by a voltage applied to pin 2. If this pin is left open circuit an internal reference of 75 mV supervenes and the holding current is given by :

$$I_h = \frac{I_p}{6}$$

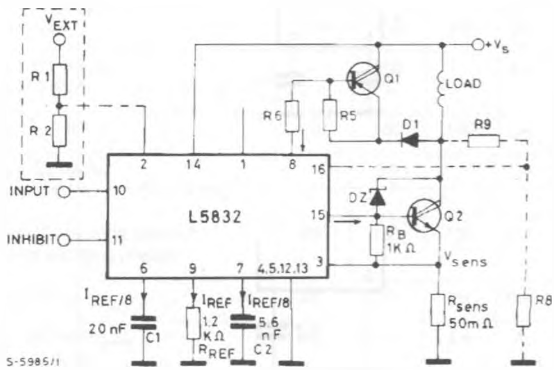
Alternatively, this level may be varied by adding a divider to pin 2 (R1, R2) and suitable values are found from :

$$\frac{I_h}{I_p} = \frac{1}{0.45\,V}\left(\frac{R2 \,//\, R_{in}}{R1 + R2 \,//\, R_{in}}\,V_{ext} + \frac{R2 \,//\, R_{in}}{Rx = R2 \,//\, R_{in}}\,Vx\right)$$

where $Vx = 3V$, $Rx = 5850\Omega$, $R_{in} = 150\Omega$ (R_{in} of pin 2) and V_{ext} is the external voltage applied to the divider.

Figure 2 : Application Circuit Showing all the Optional Components. In Particular it Illustrates how the Holding Current Level is Adjusted Independently of the Peak Current (with R1, R2, V_{ext}) and how the Internal Zener Clamp is Connected. This Circuit Produces the Waveforms Shown in Fig.3.

I_o (A)	Q1	Q2
4	BDX54	BDX53
8	BDW94	BDW93
12	BDV64	BDV65



The drive currents for the two darlingtons and the waveform time constants are all defined by a reference current, I_{ref}, which is defined in turn by a resistor between pin 9 and ground.

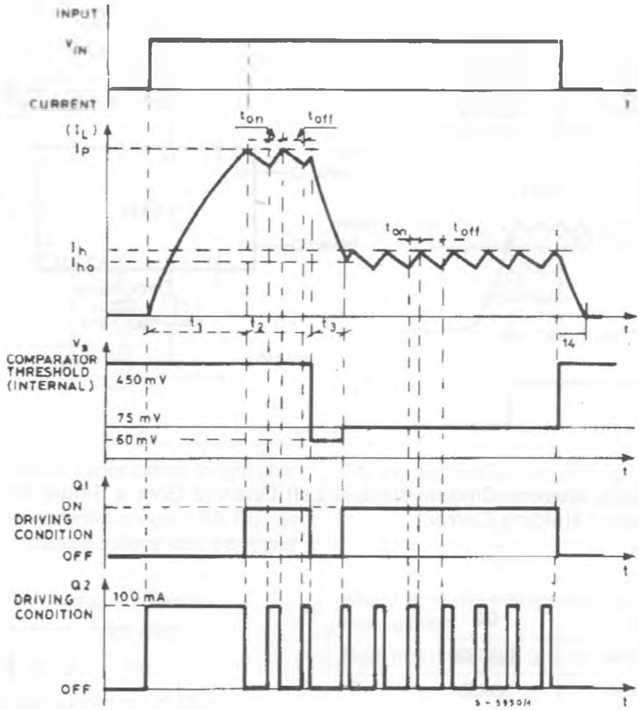
The recommended value for I_{ref} is 1 mA which is obtained with a 1.2 kΩ resistor. From I_{ref} the darlington drive currents are given by :

PNP : $I = 35\ I_{ref}$
NPN : $I = 100\ I_{ref}$

The duration of the high current level (t2 in figure 3) is set by a capacitor connected between pin 6 and ground. This capacitor, C1, is related to the duration, T, by :

$$C1 = \frac{I_{ref}\,T}{12}$$

Figure 3 : Waveforms of the Typical Application Circuit of Fig. 2.



The discharge time constant (t_{off} in figure 3) is set by a capacitor between pin 7 and ground and is found from :

$$t_{off} = \frac{12C2}{I_{ref}}$$

The t_{off} and t_{on} times are also related to the current ripple , ΔI :

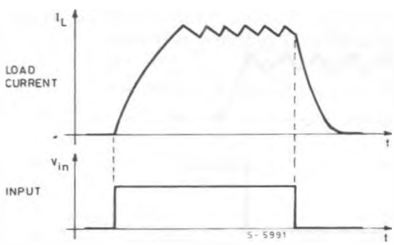
$$t_{off} = \frac{L\Delta I}{V_{off}} \quad \text{and } t_{on} = \frac{L\Delta I}{V_{on}}$$

where $V_{off} = V_{diode} + V_{CEQ1} + R_L\, I_L$
$V_{on} = V_s - V_{CEQ2} - V_{RS} - R_L\, I_L$
L = load inductance
R_L = load resistance
Δ I = load current ripple.

Note that t_{off} is the same for both the peak and holding currents.

Figure 4 : When Pin 6 in Grounded, as Shown here, the Load Current is Regulated at a Single Level.

I_o(A)	Q1	Q2
4	BDX54	BDX53
8	BDW94	BDW93
10	BDV64	BDV65



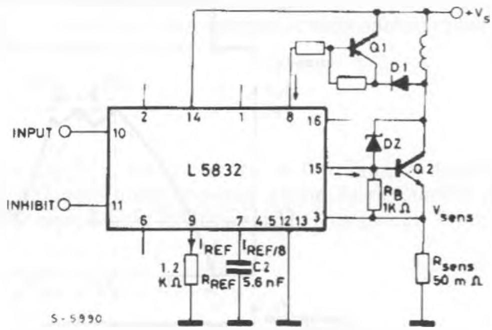
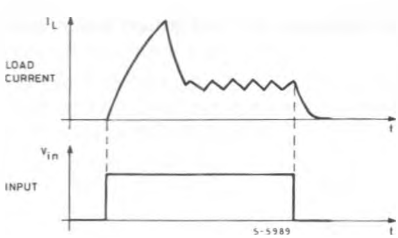


Figure 5 : In this Application Circuit, Pin 6 is Left Open to Give a Single Peak Followed by a Regulated Holding Current.

I_o(A)	Q1	Q2
4	BDX54	BDX53
8	BDX54	BDX53
16	BDW94	BDV65



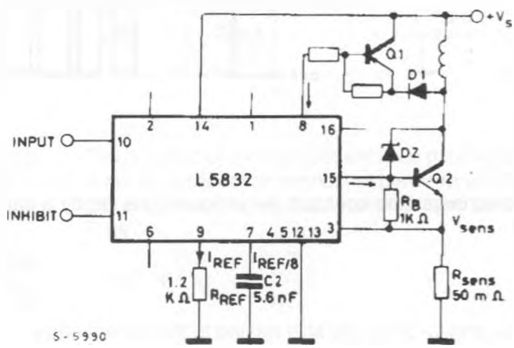
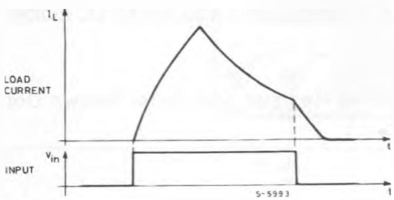
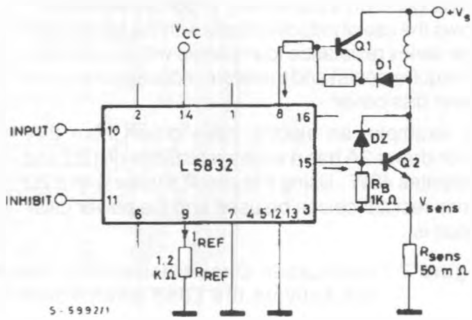


Figure 6 : Switchmode Control of the Current can be Suppressed Entirely by Leaving Pin 6 Open and Grounding Pin 7. The Peak Current is still Controlled.

I_o(A)	Q1	Q2
4	BDX54	BDX53
8	BDW94	BDW93
10	BDV64	BDV65





For fast turnoff an internal zener clamp is available on pin 16.

This is used with an external divider, R8 R9, as shown in figure 2. Suitable values can be found from :

$$V_{pin\,16} \cong 15V + V_{BEQ2} + VRsense$$

$$V_{CQ2} \cong V_{pin16} \cdot \frac{R9 + R8}{R8}$$

(V_{CQ2} is the voltage at the collector of Q2).

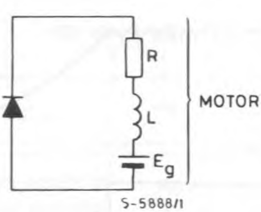
To ensure stability, a small capacitor (about 200 pF) must be connected between the base and collector of Q2 when pin 16 is used.

For the application circuit of figure 7 $t_{off} = 12C2/I_{ref}$, as before, and the current ripple is given by :

$$t_{off} = -\frac{L}{R} \quad \frac{\ln(I_{LP} - \Delta I) \cdot R_L + V_L}{I_{LP} \cdot R_L + V_L}$$

where V_L is the voltage across the inductor during recirculation.

Note that if the load is a motor $V_L = Eg + V_D$.



Normally ΔI is a design parameter therefore C2 can be calculated directly from :

$$C2 = \frac{-I_{ref} \cdot L}{12\,R_L} \cdot \frac{\ln(I_{LP} - \Delta I)\,R_L + V_L}{I_{LP} \cdot R_L + V_L}$$

This application is particularly important because it allows the use of inductive loads with the lowest possible series resistance (compatible with constructional requirements) and therefore reduces notably the power dissipation.

For example, an electric valve driven from 24V which draws 2A has a series resistance of 12Ω and dissipates 48W . Using this circuit a valve with a 2Ω series resistance can be used and the power dissipation is :

$$Pd = R_L I_L^2 + V_D I_L(1-\delta) + V_{sat} \cdot I_L\,\delta + R_S I_L 2\delta$$

where
R_L = resistance of valve = 2Ω
V_D = drop across diode, $V_D \cong 1V$
V_{sat} = saturation voltage of Q2, $\cong$ 1V
R_S = R11 = 220 mΩ
δ = duty cycle = 20 %

therefore :

$$Pd = 8 + 1.6 + 0.4 + 0.16 = 10.16W$$

This given two advantages : the size (and cost) of the valve is reduced and the drive current is reduced from 2A to about 0.4A.

The same consideration is also true for DC motors.

Figure 7 : Application Circuit Using Only one Darlington. The Resistor and Zener Shown Dotted Activate the Load when Power is Applied.

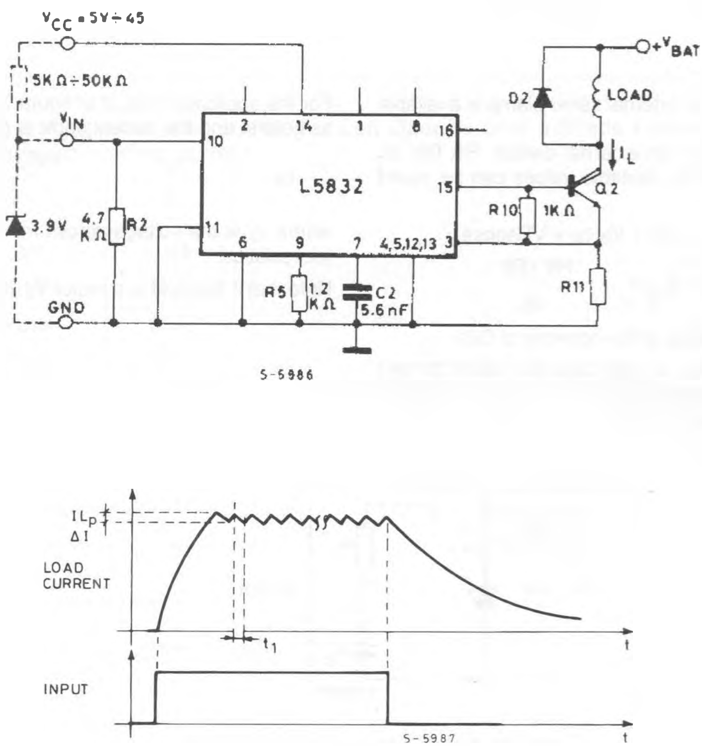


Figure 8: P.C. Board and Component Layout of the Circuit of Fig. 7 (1 : 1 Scale)

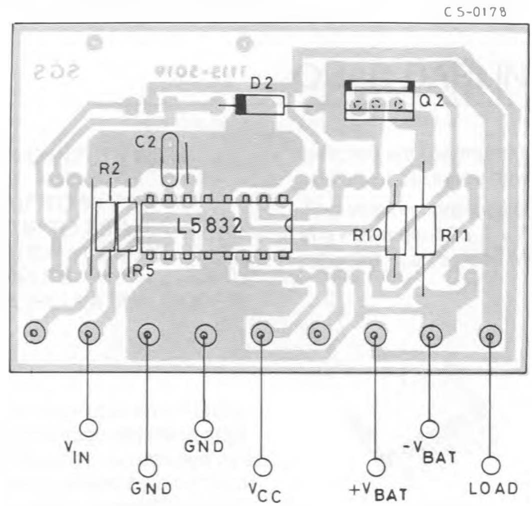
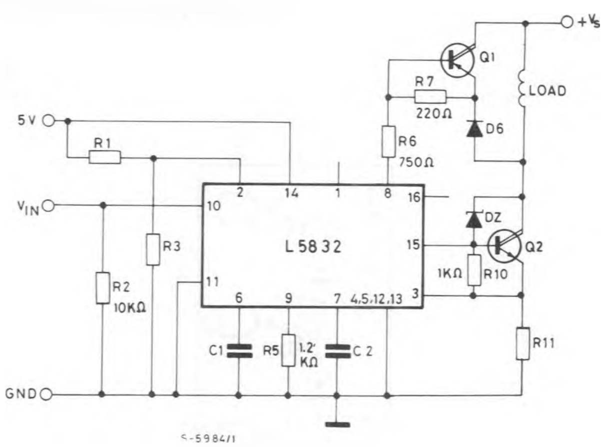


Figure 9: Application Circuit Showing how two Separate Supplies can be Used.



The application circuit of figure 9 is very similar to figure 2 except that it shows the use of two supplies-one for the control circuit, one for the power stage.

Chose R6 so that the voltage on pin 8 does not exceed 46V DC. This can be done simply bearing in mind that the pin 8 current is 35 I_{ref}.

R6 must not be too high if a very low supply voltage is used because:

$$V_{smin} = R6 \cdot 16 + 4.75$$

$$V_{smin} = 750 \cdot 35 \cdot 10^{-3} + 4.75 = 31V$$

The zener diode DZ can not exceed 62V because when Q1 is off and DZ triggered – the fast recirculation – the voltage on pin 8 may not exceed 60 V.